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# APPROPRIATE PROGRAMS FOR FOREIGN STUDENTS IN U.S. CHEMICAL ENGINEERING CURRICULA

by

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ABSTRACT

Chemical Engineers in developing countries may need abilities in a number of diverse areas including management, planning, chemistry, equipment, processes, politics, and improvisation. Chemical engineering programs for foreign students can be arranged by informed advisers with student input to include some of these areas in addition to reasonable technical knowledge for work in developing countries.

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INTRODUCTION

The education of foreign students in chemical engineering can be approached in one of at least 3 ways. One method is to consider foreign student programs as essentially the same as U.S. student programs. A second method is to devise special programs for foreign students based on faculty opinions of what foreign students need. A third method is to use the flexibility in conventional programs to supply special needs for foreign students on an individual basis. From the standpoint of cost and effectiveness, the third method seems to be the most practical and is the method discussed herein. However, the third method requires an appropriate system of advising individual students, with some knowledge or experience available on the industry and practices of other countries.

The most important factor to consider in assisting a foreign student in planning his program is that he represents a unique set of circumstances, in the background from which he came and in the situation to which he will proceed upon completion of his education. In addition, in contrast to U.S. students, the foreign student may have a better knowledge of the system to which he will return than his adviser, and may have a better knowledge of his own needs for education. Thus, each student needs to be advised on an individual basis, with consideration for both the student's opinions on the type of courses he needs and the adviser's knowledge of technical matters and course contents involved.

All the aspects of advising foreign students cannot possibly be covered in a paper such as this, and for this reason only a

small part of the problem will be discussed, primarily as an example of the factors involved. Discussion will be limited to students from developing countries who plan to return to a developing country. This limitation is chosen because most foreign students in the U.S. are from countries with only partially developed industrial systems, because most of the world's population lives in developing countries, and because the differences between U.S. student needs and foreign student needs are the most pronounced for students from developing countries.

The purpose of this paper is to illustrate the needs of chemical engineers in developing countries and to suggest how their programs can be improved to meet these needs.

## THE CHEMICAL INDUSTRY IN DEVELOPING COUNTRIES

Before considering the types of work a chemical engineer will do in a developing economy, we should consider the existing situation in the chemical and related industries and the chemical engineer's environment in such a country.

Table I is a list of chemical and process industries operating in a developing country (Vietnam), even during a protracted war. This table is divided according to industry size because there are two relatively definite size classifications normally with two different types of management. Also shown are some industries for which expansion seems eventually likely.

The larger industries are normally owned and operated by the national government, large foreign corporations, wealthy influ-

TABLE I

Chemical and Related Industries in
a Developing Country (Vietnam)

| Present Situation | | Possible Future Expansions Based on Relationship to Present Industries or Large Markets |
|---|---|---|
| Large Scale | Small Scale | |
| Natural Rubber | Ceramics | Basic Petrochemicals |
| Cement | Bricks | Fuels |
| Sugar | Food Products | Lubricants |
| Textiles | Spices & Sauces | Solvents |
| Soap & Detergents | Building Materials | Ammonia |
| Paper | Boats | Hydrogen |
| Vegetable Oils | Cleaning Supplies | DDT |
| Glass | Beverages | Polyethylene |
| Asbestos-Cement Products | Lumber | Fertilizers |
| Sodium Glutamate | Plastic Products | Paints |
| Beverages | Minerals | Building Materials |
| Chlorine | Charcoal | Rubber Products |
| Sodium Hydroxide | Scrap Metal Recovery | Agriculture Chemicals |
| | Housewares | Fishing Equipment |
| | | Metals |
| | | Plywood |
| | | Food Freezing |

ential families or individuals, or a combination of these. The smaller industries are generally owned and managed by relatively wealthy but not necessarily influential families. The smaller industries may be partially or completely operated on the basis of long-static simple technology, while the larger industries will probably be based in part on imported designs and more modern technology. The smaller industries collectively usually employ and affect more people. There is a tendency in government investment and currency exchange decisions to neglect the smaller industries and concentrate attention on large-scale industries. However, it is probably much easier to expand production or introduce new products in an existing small industry than it is to initiate a new large-scale process. Probably considerably more attention should be given to improving existing small-scale industry, and an appropriate evaluation technique should give equivalent treatment to large and small industries. Government or investor attitudes that small-scale industries are too insignificant or too "backward" to be worth assistance or attention could mean that these industries will remain insignificant and backward. Actually, the development of most modern industry has come about through expansion, modernization, and new products of previously existing corporations and industries. Even the aircraft industry originated from a bicycle shop, and DuPont evolved from a gunpowder plant. Modern development of industry may be more complex, but the possibilities of expansion and new products from existing industry should not be ignored.

In general, the products of industry in developing countries

will be more of the natural products type, such as food, fibers, vegetable and animal fats and oils, natural polymers, adhesives and coatings, and various flavors and aromatics. Also raw materials processing and products a few steps removed from raw materials will make up a larger fraction of the industrial products. Examples would include basic petroleum products, beneficiated ores, cement, ceramics, basic inorganic chemicals, fertilizers, and various building materials. In addition, mixing, molding, extrusion, fabrication, and distribution of imported chemical products will be a more important fraction of the chemical industry.

## CHARACTERISTICS AND CONDITIONS OF CHEMICAL ENGINEERING WORK IN DEVELOPING COUNTRIES

Some of the types of work chemical engineers may be called on to perform in developing countries are shown in Table II. Some of the differences between chemical engineering work in a developing country compared to an industrialized country are as follows:

Production scale will be smaller and investments will be more difficult to justify.

Political factors will be more important due to currency and capital restrictions.

Experienced specialist co-workers are not likely to be available for assistance.

Less assistance and support by people, computers, and administration may be available.

More functions will be required of one engineer.

TABLE II

Types of Work Which Can Be Performed by Chemical Engineers in a Developing Country

Management and Administration (Government, Private Industry, Foreign Corporations)

Allocation of Capital to Various Possible Investments
Planning and Scheduling of Developments
Marketing (Market Research, Sales, Customer Service)
Liason on Design and Construction Work

Design

Design for Maintenance and Repairs
Design for Local Equipment Manufacture (Parts, Replacements)
Improvements
Expansions
(Most Complete Plant Designs will Probably be Foreign)

Production Operations

Supervision of Production
Supervision of Analysis, Testing, and Quality Control
Operating Labor Training
Materials Accounting and Control
Process Improvement
Scheduling Production
Data Collection Analysis and Correlation
Problem Location and Solution (Trouble-Shooting)

Research and Development

Product Development
Raw Material Evaluations
Process Expansion
Process and Equipment Modification

Teaching

With Part-Time Employment
With Government or Other Supported Research
With Consulting

Literature, equipment, supplies, parts will be more difficult to obtain.

Supervision, owners, and government officials will have less understanding of chemical processing and chemical engineering.

Work with small-scale industries may be available only on a part-time or consulting basis and process information may be more difficult to obtain.

Economic factors are more complex and more dependent on the international economy and trade restrictions.

Engineering work and improvements may be simpler.

Competition may be much less.

Opportunities to make improvements may be much greater.

More improvisation and innovation may be necessary due to shortages, long delivery times, and small-scale operations.

Engineers in developing countries may need to organize and develop methods of working with small industries that may not be able to afford hiring a full-time engineer. Also many chemical engineers may be the only chemical engineer in their company and will have little chance to learn from others in the profession.

A type of employment, which seems likely to become more important in the future, is in sales and technical service of imported chemical products and equipment. In the U.S., much of the technology used by small industries is obtained from the sales and service organizations of the larger chemical and equipment companies. It seems likely that in the future such a pattern will develop more

extensively in the developing countries with respect to imported chemicals and equipment. Employment in this capacity with either foreign companies or local importers could be quite important in technology and information transfer.

A critical factor in any engineer's performance is access to the technical literature. In developing countries, where an engineer may be more dependent on the literature for a wider variety of responsibilities and has less access to help from other engineers, the optimum use of technical libraries is even more important than in a developed country.

In addition to problems due to lack of assistance, support, facilities, and information, the lack of an existing experienced engineering population may require that a young engineer take on responsibilities much advanced from the responsibilities of similar engineers in the U.S. This may be particularly true in government planning agencies and the larger family or government corporations.

The chemical engineering educator may be required to find part-time non-academic employment to earn a reasonable salary or may provide advice or other services to government agencies. He may also need to improvise both educational and research equipment. In general, the chemical engineer in a developing country is likely to be required to be more diversified in his activities than a chemical engineer in an industrialized country. Such diversity is likely to involve more political, economic, management, social, cultural, and improvisation considerations than in an industrialized country.

RECOMMENDATIONS FOR FOREIGN STUDENT PROGRAMS IN CHEMICAL ENGINEERING

At the University of Missouri-Rolla, all freshman have the same advisor for their first year, but are also assigned another faculty member as a permanent undergraduate advisor. Unless there are special reasons otherwise, the writer takes all foreign undergraduate chemical engineers as advisees. This allows one person to give special attention to the needs and problems of the foreign students. Foreign graduate students are advised by their major professor, and often informally consult other faculty about their programs.

In advising a foreign student as to courses he or she should study, it is important for the adviser to try to understand the status of the chemical industry in the student's country and the role the student realistically expects to take in his country. This understanding could be very difficult to achieve because of language and vocabulary problems and also because of both student and adviser's lack of knowledge, but the attempt is worthwhile and repeated conversations may be able to yield the desired understanding. The adviser should give consideration to the student's opinion on what is important in his country and then the adviser's opinion on courses and technical methods should be applied to developing the student's program.

It is also a good idea for an adviser of chemical engineering foreign students to be familiar with the chemical industry on an international scale and also with international economic development problems. The chemical news magazines are

good sources of information, and there are a number of books on economic development. Some useful sources are the UN Statistical Yearbook, Hoelscher and Hawk (1969) which includes articles on Engineering Education, Meier (1970) which discusses the role of education. Technos, the journal of the ASEE International Division is a continuing source of information useful in advising international students.

In recommending a program for a foreign student, one might first pick a hypothetical American student situation somewhat analogous to the foreign student's and consider what he would recommend for the American student. For example, what would you recommend for a student who wanted to enter his family's company in the export-import chemical business or one who expected to work as the only chemical engineer for a small home town plastic housewares fabricator? It is possible that one of the shortcomings of chemical engineering education is that it seems almost completely dominated by education for the large industry type of employer, and gives little consideration to the needs of small industries, even those that involve chemical reactions and separations. However, in spite of this, the basic required chemical engineering curricula with appropriate choices of electives and possibly a few special approval substitutions and special projects or readings could be a suitable background for a wide variety of unique situations.

## RECOMMENDATIONS FOR UNDERGRADUATE PROGRAMS

On the undergraduate level, the foreign student like the

American student needs primarily to develop chemical engineering problem-solving abilities of many types. Thus, the conventional undergraduate requirements should probably be modified to only a slight extent or not at all. To the extent that technical electives exist, special projects, special readings, emphasizing individual work, improvisation, library work, equipment, and particular types of processing may develop abilities needed and desired by the student. Additional chemistry courses related to certain industries of interest may also be helpful (such as advanced inorganic, organic, polymers, biochemistry). For planning, management, or small company type careers, technical electives in industrial or management engineering, statistics and quality control, economics, operations research, or similar fields could be very helpful.

Humanistic and social studies courses are also important to careers which may depend on politics, the international economy, and culture to a large extent. Particularly useful courses may be in ecnomics, political science, philosophy (logic), history, and others. Because of the importance of understanding the English language and the proper interpretation of subtle meanings in these courses, it may be beneficial to schedule these courses later in some students' programs when they have had time to develop a better vocabulary. Students with difficulty in English will probably learn more and also spend less time and energy if they take English, History, and similar "heavy reading" courses later in their program.

Of the total coursework in an undergraduate curriculum, probably 10 to 15% can probably be selected to suit the more specific needs of foreign students and the student can still achieve the necessary basic engineering capabilities.

RECOMMENDATIONS FOR GRADUATE PROGRAMS

Graduate programs have much more flexibility, possibly up to 50%, for students to take courses to fit their special needs, and foreign students can utilize this flexibility to obtain an appropriate background for their expected future. The basic problem-solving abilities should be improved but the foreign student should not try to pursue a number of "advanced", "sophisticated", or "popular" courses just because of current trends in the U.S. It may be more important to obtain more basic knowledge in such fields as industrial engineering, chemistry, international economics, courses related to equipment design or process strategy, and special projects and readings for individual work. Even the future chemical engineering educator should not try to attain an advanced level of competence in too many areas, but should probably reach a broader more basic competence with special advanced competence in an area needed in the school where he will teach.

Research projects for foreign graduate students are mostly determined by their major professors and available facilities, support, etc. However, where there are multiple opportunities, in most cases it would be more appropriate for the students to work with equipment or processes or techniques requiring innovation, improvisation, and individual responsibility for planning.

Since they will probably work primarily on basic practical problems in the future, it might be advisable to concentrate on this type of graduate research if possible.

The use of computers is gaining in importance in the developing countries, but not to the same extent as in the developed countries. For this reason, it is probably important for the foreign student to obtain computer programming abilities and to use the computer for research work. On the other hand, research on chemical engineering computer methods is probably of doubtful use to many foreign students who will return, except in special cases.

## CONCLUSIONS

Students from developing countries who return will probably be working in a considerably different situation from most American students, and for this reason some differences in programs are needed for such students in chemical engineering.

Along with basic chemical engineering problem-solving abilities, a foreign student may need additional abilities in planning, management, equipment, and process improvisation and some of these topics can be provided in the undergraduate curriculum by proper selection of electives and social sciences courses.

In graduate programs, both coursework and research can be oriented to the individual's probable future situation in practical problem-solving of various types.

Advising foreign chemical engineering students depends strongly on the students probable future work, and should be based on the student's and adviser's knowledge of the student's country, the student's individual circumstances, and the adviser's knowledge of available coursework and the possibilities of special projects.

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